

CLAIMS

1. A compressor system comprising

(a) a first compressor having a first stage and a second stage wherein the first stage of the first compressor is adapted to compress a first gas and the second stage of the first compressor is adapted to compress a combination of a fourth gas and an intermediate compressed gas from the first stage of the first compressor; and

(b) a second compressor having a first stage and a second stage wherein the first stage of the second compressor is adapted to compress a second gas and the second stage of the second compressor is adapted to compress a combination of a third gas and an intermediate compressed gas from the first stage of the second compressor;

wherein the first gas is at a first pressure, the second gas is at a second pressure higher than the first pressure, the third gas is at a third pressure higher than the second pressure, and the fourth gas is at a fourth pressure higher than the third pressure.

2. The system of Claim 1 which further comprises piping means to combine the discharge from the second stage of the first compressor and the discharge from the second stage of the second compressor to provide a combined compressed gas.

3. A method for gas compression comprising

(a) compressing a first gas in a first stage of a first compressor and compressing in a second stage of the first compressor a combination of a fourth gas and an intermediate compressed gas from the first stage of the first compressor, and withdrawing a first compressed gas stream from the second stage of the first compressor;

(b) compressing a second gas in a first stage of a second compressor and compressing in a second stage of the second compressor a combination of a

third gas and an intermediate compressed gas from the first stage of the second compressor, and withdrawing a second compressed gas stream from the second stage of the second compressor; and

- 5 (c) combining the first compressed gas stream and the second compressed gas stream to provide a final compressed gas stream;

wherein the first gas is at a first pressure, the second gas is at a second pressure higher than the first pressure, the third gas is at a third pressure higher than the second pressure, the fourth gas is at a fourth pressure higher than the third pressure, and the final compressed gas stream is at a final pressure higher than the fourth pressure.

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4. The method of Claim 3 wherein any of the first, second, third, and fourth gases is a refrigerant gas provided from a refrigeration system and the final compressed gas stream is a compressed refrigerant gas provided to the refrigeration system.

- 15 5. A refrigeration system for providing refrigeration at multiple temperature levels comprising

(a) a compressor system for providing a compressed refrigerant gas, wherein the compressor system includes

- 20 (1) a first compressor having a first stage and a second stage wherein the first stage of the first compressor is adapted to compress a first refrigerant gas and the second stage of the first compressor is adapted to compress a combination of a fourth refrigerant gas and an intermediate compressed refrigerant gas from the first stage of the first compressor; and

- 25 (2) a second compressor having a first stage and a second stage wherein the first stage of the second compressor is adapted to compress a second refrigerant gas and the second stage of the second compressor is adapted to compress a combination of a third refrigerant gas and an

intermediate compressed refrigerant gas from the first stage of the second compressor; and

5 (3) piping means to combine the discharge from the second stage of the first compressor and the discharge from the second stage of the second compressor to provide the compressed refrigerant gas;

wherein the first refrigerant gas is at a first pressure, the second refrigerant gas is at a second pressure higher than the first pressure, the third refrigerant gas is at a third pressure higher than the second pressure, and the fourth refrigerant gas is at a fourth pressure higher than
10 the third pressure;

(b) a compressor aftercooler to cool and condense the compressed refrigerant gas, thereby providing a condensed refrigerant stream; and

(c) a refrigeration apparatus adapted to provide refrigeration in four temperature ranges, wherein the refrigerant apparatus comprises

15 (1) first pressure reduction means to reduce the pressure of the condensed refrigerant stream to the fourth pressure, thereby providing a reduced-pressure refrigerant liquid at the fourth pressure;

(2) piping means to divide the reduced-pressure refrigerant liquid at the fourth pressure into a first refrigerant portion and a second
20 refrigerant portion at the fourth pressure;

(3) heat exchange means to vaporize the first refrigerant portion of (2) at the fourth pressure, thereby providing refrigeration in a first temperature range and providing the fourth refrigerant gas;

25 (4) second pressure reduction means to reduce the pressure of the second refrigerant portion of (2) from the fourth pressure to the third pressure, thereby providing a reduced-pressure refrigerant at the third pressure;

(5) piping means to divide the reduced-pressure refrigerant liquid at the third pressure into a first refrigerant portion and a second refrigerant portion at the third pressure;

5 (6) heat exchange means to vaporize the first refrigerant portion of (5) at the third pressure, thereby providing refrigeration in a second temperature range and providing the third refrigerant gas;

10 (7) third pressure reduction means to reduce the pressure of the second refrigerant portion of (5) from the third pressure to the second pressure, thereby providing a reduced-pressure refrigerant at the second pressure;

(8) piping means to divide the reduced-pressure refrigerant liquid at the second pressure into a first refrigerant portion and a second refrigerant portion at the second pressure;

15 (9) heat exchange means to vaporize the first refrigerant portion of (8) at the second pressure, thereby providing refrigeration in a third temperature range and providing the second refrigerant gas;

20 (10) fourth pressure reduction means to reduce the pressure of the second refrigerant portion of (8) from the second pressure to the first pressure, thereby providing a reduced-pressure refrigerant at the first pressure; and

(11) heat exchange means to vaporize the reduced-pressure refrigerant at the first pressure, thereby providing refrigeration in a fourth temperature range and providing the first refrigerant gas.

25 6. The refrigeration system of Claim 5 wherein the refrigeration apparatus is adapted to cool another compressed refrigerant gas.

7. The refrigeration system of Claim 5 wherein the refrigeration apparatus is adapted to precool natural gas prior to liquefaction.

8. A refrigeration process comprising

5 (a) providing a compressor system including

(1) a first compressor having a first stage and a second stage wherein the first stage of the first compressor is adapted to compress a first refrigerant gas and the second stage of the first compressor is adapted to compress a combination of a fourth refrigerant gas and an intermediate compressed refrigerant gas from the first stage of the first compressor; and

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(2) a second compressor having a first stage and a second stage wherein the first stage of the second compressor is adapted to compress a second refrigerant gas and the second stage of the second compressor is adapted to compress a combination of a third refrigerant gas and an intermediate compressed refrigerant gas from the first stage of the second compressor; and

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(3) piping means to combine the discharge from the second stage of the first compressor and the discharge from the second stage of the second compressor to provide a compressed refrigerant gas;

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wherein the first refrigerant gas is at a first pressure, the second refrigerant gas is at a second pressure higher than the first pressure, the third refrigerant gas is at a third pressure higher than the second pressure, and the fourth refrigerant gas is at a fourth pressure higher than the third pressure;

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(b) compressing a refrigerant gas in the compressor system of (a) to provide a compressed refrigerant gas;

(c) cooling and condensing the compressed refrigerant gas, thereby providing a condensed refrigerant stream; and

(d) providing refrigeration in four temperature ranges by

(1) reducing the pressure of the condensed refrigerant stream to the fourth pressure, thereby providing a reduced-pressure refrigerant liquid at the fourth pressure;

5 (2) dividing the reduced-pressure refrigerant liquid at the fourth pressure into a first refrigerant portion and a second refrigerant portion at the fourth pressure;

(3) vaporizing the first refrigerant portion of (2) at the fourth pressure, thereby providing refrigeration in a first temperature range and providing the fourth refrigerant gas;

(4) reducing the pressure of the second refrigerant portion of (2) from the fourth pressure to the third pressure, thereby providing a reduced-pressure refrigerant at the third pressure;

15 (5) dividing the reduced-pressure refrigerant liquid at the third pressure into a first refrigerant portion and a second refrigerant portion at the third pressure;

(6) vaporizing the first refrigerant portion of (5) at the third pressure, thereby providing refrigeration in a second temperature range and providing the third refrigerant gas;

20 (7) reducing the pressure of the second refrigerant portion of (5) from the third pressure to the second pressure, thereby providing a reduced-pressure refrigerant at the second pressure;

(8) dividing the reduced-pressure refrigerant liquid at the second pressure into a first refrigerant portion and a second refrigerant portion at the second pressure;

25 (9) vaporizing the first refrigerant portion of (8) at the second pressure, thereby providing refrigeration in a third temperature range and providing the second refrigerant gas;

(10) reducing the pressure of the second refrigerant portion of (8) from the second pressure to the first pressure, thereby providing a reduced-pressure refrigerant at the first pressure; and

5 (11) vaporizing the reduced-pressure refrigerant at the first pressure, thereby providing refrigeration in a fourth temperature range and providing the first refrigerant gas.

9. The process of Claim 8 which further comprises cooling an additional compressed refrigerant gas by the refrigeration provided in at least one of the first, second, third, and
10 fourth temperature ranges.

10. The process of Claim 8 wherein the additional compressed refrigerant gas is a mixed refrigerant gas containing two or more components selected from the group consisting of nitrogen and hydrocarbons having from one to five carbon atoms.

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11. The process of Claim 8 which further comprises precooling natural gas prior to liquefaction by the refrigeration provided in at least one of the first, second, third, and fourth temperature ranges.

20 12. The process of Claim 8 wherein the compressed refrigerant gas is a single component selected from hydrocarbons having from two to four carbon atoms.

13. The process of Claim 8 wherein the compressed refrigerant gas comprises two or more components selected from the group consisting of nitrogen and hydrocarbons
25 having from one to five carbon atoms.